Twenty Years of VV&A:
Tomahawk Simulation Management Lessons Learned

The Johns Hopkins University Applied Physics Laboratory

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Discussion Points

- **Tomahawk Simulation Management thumbnail overview**
- **Vetting the lessons learned process**
- **Tomahawk Simulation Management and VV&A lessons learned**
- **Summary**

Motivation for the Lessons Learned

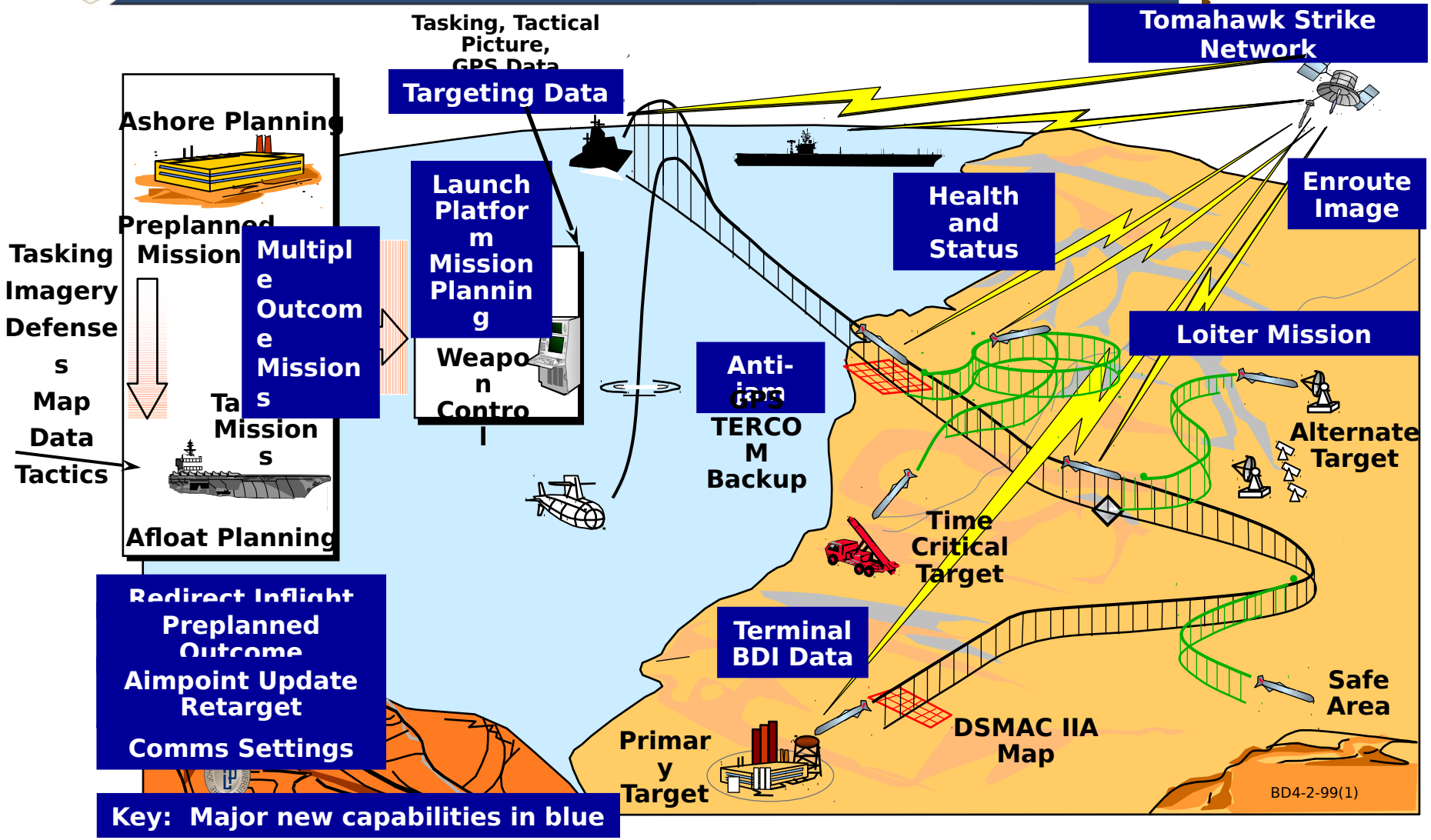
- **The Tomahawk program has been practicing modeling and simulation (M&S) management and verification, validation, and accreditation (VV&A) since 1983.**

- **Tomahawk Simulation Management results in accredited simulations and test configurations having clearly specified representations and well-defined applicability.**

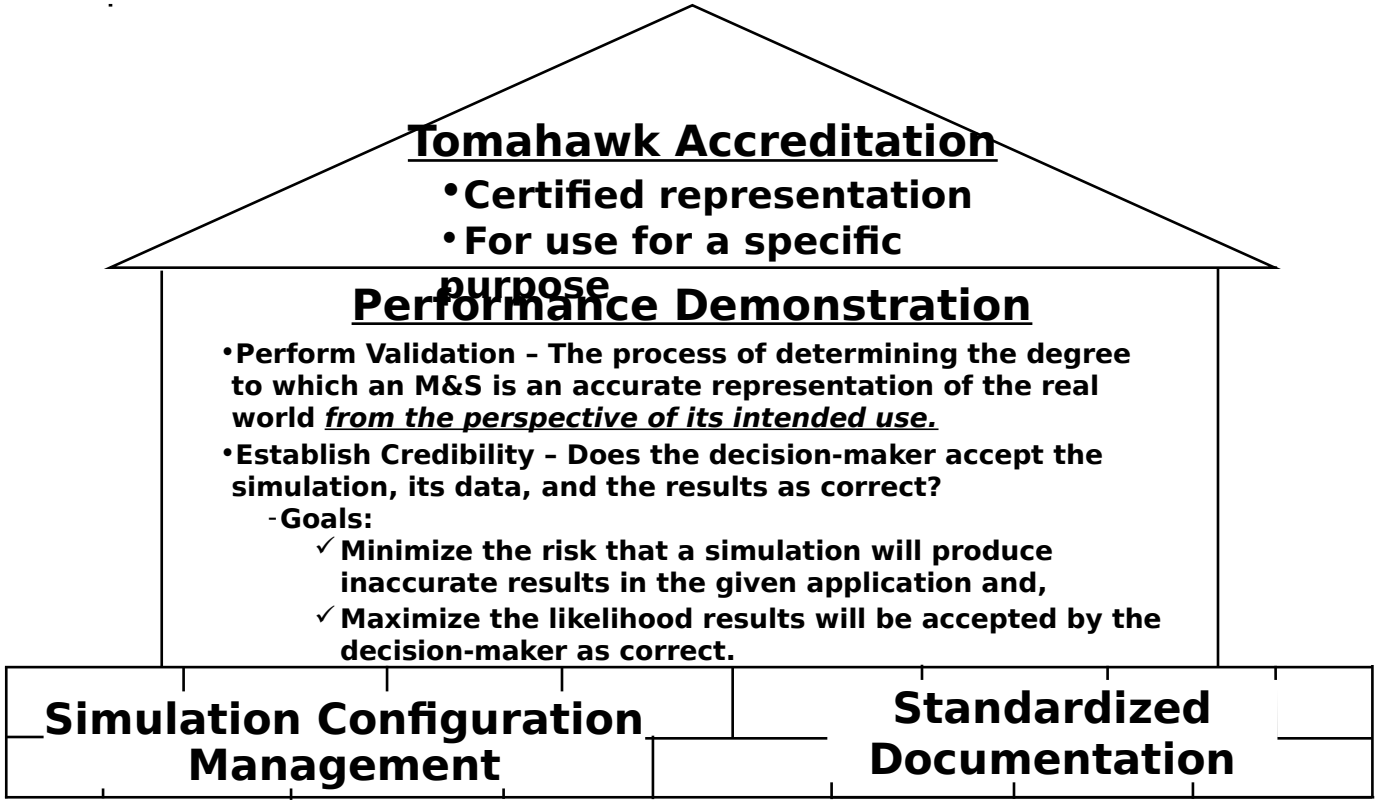
- **The Navy's operational test community views Tomahawk simulation management favorably.**

- **Simulation management "lessons learned" may benefit other Navy programs seeking to implement sound VV&A.**

Tactical Tomahawk Overview

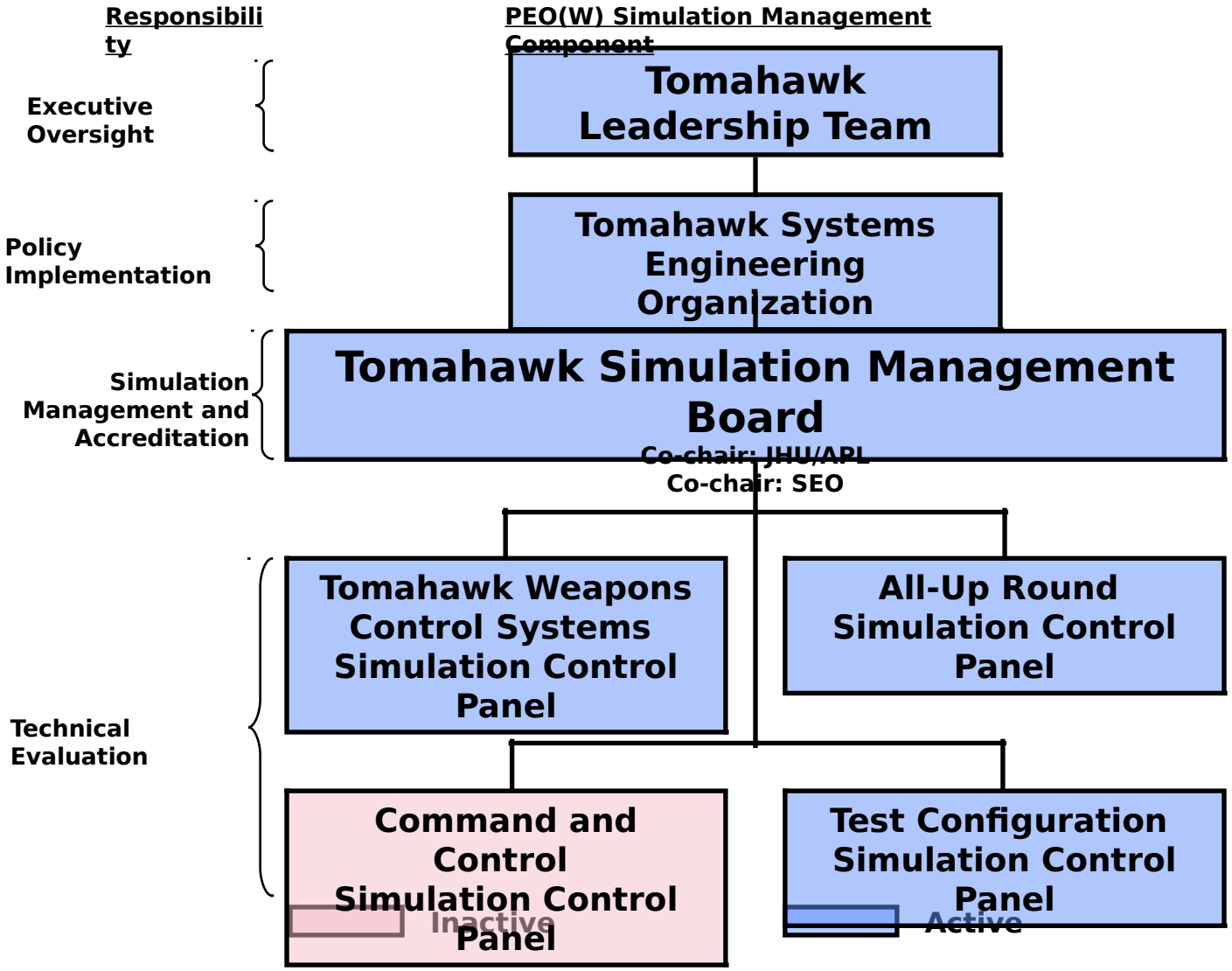


Building Tomahawk Simulation Accreditation


Tomahawk Accreditation
•Certified representation
•For use for a specific purpose
Performance Demonstration
•Perform Validation – The process of determining the degree to which an M&S is an accurate representation of the real world from the perspective of its intended use.
•Establish Credibility – Does the decision-maker accept the simulation, its data, and the results as correct?
-Goals:
✓Minimize the risk that a simulation will produce inaccurate results in the given application and,
✓Maximize the likelihood results will be accepted by the decision-maker as correct.
Simulation Configuration Management
Standardized Documentation

- **Tomahawk Simulation Management defining documents**
  1. SECNAVINST 5200.40 – *Verification, Validation, and Accreditation (VV&A) of Models and Simulations*
  2. Tomahawk Simulation Management Policy – *PEO(W) instruction specifying scope, applicability, and responsibilities*.
  3. Tomahawk Simulation Management Plan (TSMP) – *Provides process specifics for policy implementation.*
  4. Tomahawk Simulation Management Overview – *"Tomahawk Simulation Management 101" introduction.*
- **Tomahawk Simulation Management Board was established in 1983 under charter from Joint Cruise Missiles Project Office.**

Tomahawk Simulation Management *Organization*



Tomahawk Simulation Management
Tomahawk Simulation Management Board

- **Tomahawk Simulation Management Board (TSMB) is the principal agent for development and implementation of the Tomahawk Simulation Management Plan and VV&A processes and activities.**
  - **Membership selected from PEO(W), JHU/APL, Navy Laboratories, and Navy field activities.**
  - **Responsibilities include:**
    - **Review simulations for accreditation and accreditation update based on recommendations received from the Simulation Control Panels.**
    - **Ensure authorized Tomahawk simulations are identified, technically characterized, and documented in the Tomahawk Simulation Catalog.**
    - **Maintain the Tomahawk Simulation Archive.**
    - **Provide program-specific M&S management expertise and coordination among programs.**

Tomahawk Simulation Management
Simulation Control Panels

- **Simulation Control Panels (SCPs) are staffed with subject matter experts.**
  - **Responsibilities**
    - **Provide technical support to the TSMB**
    - **Technical review of simulation verification and validation data**
    - **Recommends accreditation to the TSMB**
    - **Maintains accreditation plans and schedules**
  - **Subject matter experts (SMEs) drawn from organizations throughout the Tomahawk program. Experts in Tomahawk, flight dynamics, weapon control system components, simulation, VV&A, and T&E.**
    - **SCP is not their "day job"**
    - **Participation is expected to be long-term**
  - **Three active panels review Tomahawk simulations and test configurations for accreditation.**
    - **All-up Round SCP reviews simulations of the Tomahawk missile and missile subsystems.**
    - **Tomahawk Weapons Control Systems SCP reviews simulations of components in the various Tomahawk WCSs (TWCS, ATWCS, TTWCS).**
    - **Test Configuration SCP reviews test configurations for developmental and operational test.**

Tomahawk Simulation Management
Key Aspects of Current VV&A Process

- **Tomahawk Simulation Accreditation defines fundamental process for accreditation of simulations and test configurations.**
- **Fundamental components of VV&A**
  - **Advocacy**
  - **<u>Independent</u> assessment**
  - **Accreditation Plan and Catalog Entry**
  - **Validation adequate to justify desired accreditation**
    - **Technical review by SCPs**
    - **Defined representation and applicability**
  - **Accreditation Package**
    - **Plan, catalog entry, accreditation report, user's guide, version description document, simulation configuration management plan, source code, benchmark checkcase input data, and simulation output.**
  - **Certificate**
    - **Issued by TSMB based on accreditation package review and SCP recommendation.**

Tomahawk Simulation Management

Accreditation Template Synopsis

- **Process is applicable for accreditation of new or updated simulations as well as expanded application of an accredited simulation.**
  - **Authorize Simulation**
  - **M&S Proponent Prepares Accreditation Plan**
  - **SCP approves Accreditation Plan**
  - **Present Accreditation Report to SCP**
    - **Documents validation results of Accreditation Plan**
    - **Includes technical demonstration of correctness and consistency**
    - **SCP reviews and approves report and documentation**
  - **Certificate is awarded by TSMB after recommendation by SCP**
    - **SCP recommendation approved or action items assigned for completion prior to approval.**
    - **ALL accreditation material in Tomahawk Simulation Archive for full accreditation.**

Tomahawk Simulation Management
Tomahawk Simulation Accreditation

Full Accreditation: All requirements have been met.

Provisional Accreditation: Performance has been demonstrated but not all accreditation requirements have been satisfied. (e.g., document preparation due to inadequate funding or sponsor accreditation timeline.)

Limited Accreditation: Validation against real system data is incomplete although validation against all existing comparison data indicates correct performance and results consistent with other simulations.
- Applies to an emerging development or when no real-world data exists.
- Limitation on applicability is expressed on the certificate (e.g., Full accreditation for development flight test prediction).

Site Accreditation: Applies when an accredited Tomahawk simulation is installed and used at an additional site. Demonstrates that the new site can re-host and utilize another Tomahawk organization's simulation correctly.

- **Accreditation applies to:**
  - ✓ **All TWS models, simulations, and test configurations producing results that are presented outside the organization responsible for development.**
- **Tomahawk accreditation satisfies DON and COMOPTEVFOR requirements.**

Process for Lessons Learned

- **JHU/APL tasked with preparing PEO(W) response to COTF following 17 April 2003 request.**
- **Solicited input from TSMB members, AUR/SCP co-chairs, TWCS/SCP chair, and TC/SCP co-chairs.**
- **Prepared draft response and provided respondents opportunity for review.**
- **Final presentation delivered to SEO on 27 May 2003.**
- **Final PEO(W) briefing on 01 July 2003.**
- **Delivery to COMOPTEVFOR on 25 July 2003.**

Contributors to These Lessons Learned

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Intended Audience and Lesson Format

- **Engineers, simulation developers, and program managers *directly* responsible for implementation of a VV&A program.**

- **Lessons learned span the gamut from top level to specific.**
  - **Lessons learned document orders lessons from top level to specific.**
  - **Must be learned lesson and generalizable to other programs.**

- **Each lesson on a single chart.**
  - **Lesson Learned**
  - **Rationale – Fundamental basis for the lesson**
  - **Support – Specific evidential support for the lesson**

Tomahawk Simulation Management
The Lessons Learned

1. Simulation management pays off at the weapon systems level.
2. Run the simulation management activity as a value-added management function.
3. Accreditation finds software defects.
4. Establish program office visibility and support.
5. Create clear, well-publicized management processes.
6. Establish VV&A policies consistent with SECNAVINST 5200.40.
7. No accreditation without sponsor authorization!
8. Separate simulation management from simulation development and maintenance activities.
9. Accredit with the end-user in mind.
10. Solicit test community participation.
11. The accreditation process takes time.
12. VV&A must be ongoing.
13. Establish a program-funded archive for accreditation materials.
14. Staff SCPs with dedicated, experienced, independent experts.
15. Appropriately involve subject matter experts.
16. Maintain a technical focus during accreditation.
17. Accredit simulations for emerging developments.
18. Establish and promote site accreditation.
19. Prepare well-defined, conservative accreditation statements early in the process.
20. Achieve consensus among SCP participants.

Lessons for the Program Office

- **Simulation management pays off at the weapon systems level.**
- **Run the simulation management activity as a value-added management function.**
- **Accreditation finds software defects.**
- **Establish program office visibility and support.**
- **Establish a program-funded archive for accreditation materials.**

Lessons on the VV&A Process

- **Create clear, well-publicized management processes.**
- **Establish VV&A policies consistent with SECNAVINST 5200.40.**
- **No accreditation without sponsor authorization!**
- **Separate simulation management from simulation development and maintenance activities.**
- **Accredit simulations for emerging developments.**
- **Establish and promote site accreditation.**

Lessons for the User

- **Accredit with the end-user in mind.**

- **Solicit test community participation.**

Lessons for the M&S Proponent

- **The accreditation process takes time.**
  - **Time is required to completely understand simulation and test configuration capabilities, limitations, and actual use.**
  - **Time is required for proper assessment of technical data.**
  - **Time is required for the simulation developers performing VV&A to educate in-house program management about the extent of the VV&A process.**
  - **Time permits free exchange of ideas among the panel experts and the simulation developer. Time also gives developers adequate time to respond to action items.**
  - **Conceptual model presentations may be required.**

- **VV&A must be ongoing.**

Lessons for the VV&A Review Team

- **Staff SCPs with dedicated, experienced, independent experts.**
- **Appropriately involve subject matter experts.**
- **Maintain a technical focus during accreditation.**
- **Prepare well-defined, conservative accreditation statements early in the process.**
- **Achieve consensus among SCP participants.**

Important Lesson No.1

Simulation management must be run as and remain focused on value added.

- **Value added must benefit program, program managers, test community, simulation developers.**
- **The more value added perceived the easier participation will be.**
- **Tomahawk Simulation Management value added includes technical value, return on investment, and total program cost savings.**

Important Lesson No. 2

Technically focused accreditation builds credibility and establishes validity of models, simulations, and test configurations directly supporting the end-user and test community.

- **Technical credibility conveys its own value.**
- **Test program cannot examine full range of conditions.**
- **SCPs comprise dedicated, experienced, independent technical experts.**

Important Lesson No. 3

Simulation management pays off at the simulation, software, and weapon systems levels.

- **Primary value of accreditation at the simulation level is the scrutiny of simulation results in preparation for SCPs.**

- **Primary value of accreditation at the weapon systems level:**
  - **Standards of comparison across all simulations**
  - **Technology transfer**

- **Simulation review for VV&A has identified defects in simulations and in flight software**

Summary

- **Simulation management and VV&A processes soundly implemented benefit a program by adding value, finding system and software defects, and establishing credibility and validity of M&S assets.**
- **Robust simulation management processes help assure compliance with the intent of DOD and DON instructions.**
- **Simulation management must remain flexible and vital to avoid becoming a “check-in-the-box” for program managers.**
- **Tomahawk Simulation Management and VV&A process will continue to be assessed during Tactical Tomahawk TECHEVAL and OPEVAL for lessons learned.**